

Advanced Human Modelling Behaviours: The Key to Optimising Individual Readiness and Organisational Effectiveness

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ABSTRACT

United States Joint Forces Command (USJFCOM) Joint Training Directorate/Joint Warfighting Center (J7) supports joint warfighter development by strengthening and developing capabilities for the Joint Training Environment (JTE). USJFCOM J7 manages and develops enhancements for all joint models, federations, and tools used in the JTE. A JTE objective is to further develop human modelling concepts that focus on the tactical level of warfare involving an asymmetric opponent. Our goal is to provide realism in joint staff training, while avoiding negative consequences that could result if human reactions to combat situations are not anticipated. Human modelling within gaming technologies continues to be a critical gap in supporting increasingly complex training scenarios. Advancing human modelling behaviours is pivotal to optimizing individual readiness and organizational effectiveness to support the fight, today and in the future.

At the request of the Allied Command Transformation (ACT), USJFCOM J7 demonstrated that constructive simulations could be combined with a gaming technology, Virtual Battlespace 2 (VBS2), for the International Training and Education Conference (ITEC). The team developed scenarios to provide strategic to tactical levels of training that addressed Time Sensitive Targeting and Joint Personnel Recovery training objectives. Although the scenarios provided high fidelity, realistic training and satisfied the training objectives, they lacked sufficient realistic human modelling behaviour because of the level of difficulty to predict or control Artificial Intelligence (AI) by a single operator. Thus, they did not take into consideration neutral and other parties within the area of interest, which may not have provided a true representation of actuality of collateral damage to a civilian population in the real world.

USJFCOM J7 engineers developed new behaviours for VBS2 AI characters in order to increase the realism of the virtual environment in scenarios for the Future Immersive Training Environment (FITE) Joint Capability Technology Demonstration (JCTD), which focuses on transitioning technologies and methods that create realistic and stimulating conditions in support of human-centric decision activities. These behaviours included a variety of background "cues and indicators" that allowed VBS2 characters to engage in conversation, smoke cigarettes, play cards, and drink tea. More subtle behaviours, such as looking over one's

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shoulder, observing surreptitiously, and following at a distance, were also added. Although the realism of automated AI behaviours in virtual humans is still evolving, these advanced behaviours in the FITE scenarios have significantly made the virtual environment a much more realistic venue for small unit, tactical training.

Grounds forces are increasingly turning to gaming technologies to provide synthetic environments for realism in training for armed engagement with an asymmetric opponent in a complex environment. However, military training gaming technology software has not maximized the potential of modelling realistic human behaviours. Civilian interaction on the nonlinear battlefield is extremely unpredictable, but cannot be overlooked. The ability to identify foreshadowing behaviour (such as anxiety and nervousness) prior to a combat situation is critical. By combining gaming technologies with advanced human modelling, we will narrow the gap to meet our military's needs, maintain a technological lead, and extend our tactical edge on both the linear and nonlinear battlefield.

1.0 INTRODUCTION

The United States Joint Forces Command (USJFCOM) Joint Training Directorate/Joint Warfighting Center (J7) supports joint warfighter development by strengthening and developing capabilities (models, federations, and tools) for the Joint Training Environment (JTE). A key effort to improve the JTE is to improve human behaviour models that represent tactical, operational, and strategic problems for the training audience. The goal is to enhance the relevance of joint staff training, while avoiding consequences that could result if reactions to combat challenges resulting from behaviours unfamiliar to the joint warfighter are not anticipated.

The USJFCOM J7 mission is to train forces, develop doctrine, lead training requirements analysis, and provide a globally distributed and interoperable training environment in order to improve joint force readiness. It manages and develops enhancements for all joint models, federations, and tools used in the JTE with the objective to advance human modelling concepts that focus on the tactical level of warfare involving an asymmetric opponent. Our goal is to provide realism in joint staff training, while avoiding consequences that could result if reactions to combat challenges resulting from behaviours unfamiliar to the joint warfighter are not anticipated.

Interactions on the battlefield are extremely unpredictable, and cannot be overlooked or underestimated. The demand to provide Irregular Warfare (IW) training is increasing exponentially. Human modelling within our simulations continues to be the key proponent in supporting increasingly complex training scenarios. The ability to identify foreshadowing behaviour (such as anxiety and nervousness) prior to a combat situation is critical. Advancing the science and application of human behaviour models is pivotal to training stimuli and thus, optimising individual readiness and organisational effectiveness to support the fight today and in the future.

2.0 BACKGROUND

In 2008, USJFCOM established the Joint Irregular Warfare Center (JIWC) to proactively coordinate, prioritize, and provide subject matter expertise and partner on all IW matters. USJFCOM's goal is to ensure that the warfighters are as effective in IW as they are in conventional warfare. The joint force approach is "to prevent, deter, disrupt and defeat irregular threats, ... to work in concert with other governmental agencies and multinational partners, and, where appropriate, the host nation to understand the situation in depth, plan and act in concert, and continually assess and adapt their approach in response to the dynamic and complex nature of the problem. In order to maximize the prospect of success, the joint force must understand the population

and operating environment, including the complex historical, political, socio-cultural, religious, economic, and other causes of violent conflict.”

In 2010, the JIWC and Joint Staff J-7, co-lead analysis involving different organisations within the Department of Defense (DoD) to assess the objectives in supporting IW training. This analysis, the IW Training Simulators Integrated Product Team (IWTSIPT) Final Report, identified trends to ascertain the requirements for effective military training as it pertains to IW. Prominent in these trends is modelling human behaviours.

3.0 DISCUSSION

The physical and socio-cultural environment of IW is considerably more complex than it is for regular warfare operations. Modelling these aspects of this environment has created challenges. The IWTSIPT Final Report identified critical modelling capability advancement trends required to respond to the demands of a rapidly changing IW operational environment. USJFCOM’s J7 Joint Advanced Technologies Laboratory (JATTL) supports both current and future Joint and Coalition operations for modelling and simulation (M&S) development, integration, and testing. Significant JATTL resources are allocated to M&S activities focused on:

- Visual representation of physical behaviours, to include appearance and movement.
- Visual representation of human terrain, to include Ethnographic Intelligence (ETHINT) and Cultural Intelligence (CULINT) concepts.¹
- Visual representation of terrain, to include dynamic terrain and adaptive behaviour.

3.1 Visual Representation of Physical Behaviours

The visual representation of individuals includes their dress, height, weight, age, gender, skin colour, and facial expression. The capability to portray variations in individuals’ appearances must be substantial enough to represent a population accurately. The movements of simulated entities must be consistent, natural, and fluid. Differences between personal dress, appearance, and behaviour within various regions of a country or area of operations must also be taken into consideration. The immersive system must provide a high level of fidelity to train the warfighter in immediate identification skills that will directly impact decision making.

Pattern matching is the ability to identify and dissect visual and behavioural patterns and anomalies, classify them, and use this information to make quick recognitions and support decisions. It is a key survival trait in humans, and a powerful tool for avoiding conflict and damage in the tactical environment. Warfighters need to hone this skill to achieve objectives quickly with minimum loss of life.

Unfortunately, the better a trainee’s skill is at pattern matching, the easier it is for them to focus on nonessential patterns in the training environment. Focusing on and overanalyzing patterns resulting unintentionally from immature modelled behaviours leads to inaccurate or delayed synthesization of data, and could potentially result in a negative training outcome. For example, if a patrol (trainee) is to identify a person of interest by recognizing patterns of where he goes and with whom he talks, and the training environment is not mature enough to provide highly detailed behaviours for all entities in the scenario, the

¹ Another trend that should be considered but is not mentioned in the IWTSIPT Final Report.

focus will be more on the relationship inconsistencies. Consequently, this will affect the accomplishment of the actual training objective.

DI-Guy and Virtual Battlespace 2 (VBS2) are models currently in use by the Army and Marine Corps that attempt to provide visual representation of individuals. Both contain human representation with appropriate dress and appearance of Middle Eastern descent; however, only a few characters exist in the database. If a crowded area is modelled in a scenario, the “crowd” is replicated from existing entities with identical characteristics and gestures.

3.1.1 Examples JATTL Efforts

3.1.1.1 International Training and Education Conference (ITEC)

At the suggestion of the Allied Command Transformation (ACT), USJFCOM J7 demonstrated that constructive simulations could be combined with a gaming technology, VBS2, for ITEC2009. The team developed scenarios to provide strategic to tactical levels of training that addressed Time Sensitive Targeting (TST) and Joint Personnel Recovery training objectives. Although the scenarios provided high fidelity, realistic training and satisfied the training objectives, they lacked sufficient realistic human modelling behaviour because of the level of difficulty to predict or control Artificial Intelligence (AI) by a single operator. Thus, they did not take into consideration neutral and other parties within the area of interest, which may not have provided a true representation of actuality of collateral damage to a civilian population in the real world.

During ITEC2010, USJFCOM J7 and ACT/NATO combined efforts again to present an enhanced version of ITEC2009 demonstration by emphasizing human behaviours while completing a time sensitive targeting scenario. The possibility of collateral damage involving civilian casualties within an urban environment needs to be considered during training. The study of the human terrain is becoming increasingly important in all training aspects where collateral damage can affect the outcome of military campaigns. Organization effectiveness can be diminished when IW tactics are employed.

3.1.1.2 Future Immersive Training Environment (FITE) Joint Capability Technology Demonstration (JCTD)

USJFCOM J7 engineers developed new behaviours for VBS2 AI characters in order to increase the realism of the virtual environment in scenarios for the Future Immersive Training Environment (FITE) Joint Capability Technology Demonstration (JCTD), which focuses on transitioning technologies and methods that create robust and stimulating conditions in support of individual warfighter and small team decision activities. These behaviours included a variety of background "cues and indicators" that allow VBS2 characters to engage in conversation, smoke cigarettes, play cards, and drink tea. More subtle behaviours were also included, such as looking over one's shoulder, observing surreptitiously, and following at a distance. Although there are still improvements to be made to meet more complex and subtle training objectives, these advanced behaviours in the FITE scenarios have significantly made the virtual environment a much more useful venue for small unit, tactical training.

3.1.1.3 Commercial Games versus Serious Games

JATTL engineers continually investigate methods and tools to improve human behaviour realism; this includes evaluating commercial gaming products. Developers of commercial games are the principal pioneers

in human behaviour modelling. However, there are significant differences between the construct of commercial games for play and serious games for training. Commercial gaming is focused principally on entertainment (and sales), and only uses realism to the degree necessary to enhance this goal. Gaming scenarios are generally limited in number, deterministic, and extensively tested. In contrast, serious gaming developers provide the overall tools for the end user to assemble individual entities into a scenario to accomplish training objectives. The principal goal in serious gaming is to create a training environment that most closely replicates the operating environment, thereby demanding the highest levels of realism.

Predefined animation sequences are used to represent gross motor actions of humans in commercial games. These animations are most often generated by feeding the results of a motion capture session into a 3D modelling package. While these animations are far less computationally demanding, there are two primary drawbacks. First, they are character dependant. Second, they are immutable after they have been created. What this means is that the animation for one action is unique and distinct from the animation for a different action. Neither of these drawbacks is of particular consequence to the commercial gaming industry because of the predefined scenarios. Conversely, in the training domain, where scenarios are the product of end user creation, this animation pipeline is too rigid and time consuming. Even subtle scenario refinements to predefined animation sequences often require animations be reworked or replaced, which costs additional time and money.

3.1.2 Obstacles

Significant strides have been accomplished in the JATTL; however, issues related to human behaviour representation occur universally throughout training platforms. Two significant obstacles present a tremendous challenge for the M&S community in recreating the contemporary IW operating environment.

- *Path planning, or "How do I find my way from point A to point B".*

As humans, we approach such problems using a combination of deliberate, rational thought and experiential subconscious thought. However, there are also thousands of subconscious decision points that guide the fine grain elements of one's actions that are not consciously deliberated. These subconscious decisions are based on years of experience. They are precisely the types of decisions that a computer, which is purely a rational machine, can't make. Experiences define the complex world of humans, and will cause the trainee's "suspension of disbelief" to be instantly shattered when simple social and environmental norms are broken. So while the path planning algorithms available in modern serious games perform fairly well at the purely logical function of determining the optimal route between point A and point B, they can only approximate the latter half of the decision making process by presupposing and rationalizing what are determined to be the most likely and important subconscious decisions. This leads to autonomous humans doing things that are out of the norm, simply because everything that might occur can't be predicted. Furthermore, the branching logic in these programs often becomes so complex and unwieldy that behaviour will become too unpredictable for training. If we are simply shooting ray guns at green monsters, the fact that the green monsters start doing things that might be considered weird is just part of the entertainment. However, when trying to replicate the complex human terrain of a modern IW environment, where the difference between a civilian and an insurgent may often be subtle behavioural cues, unnatural-like behaviour can be a tremendous detriment to the training effectiveness.

- *The inability for any of the standard modelling and simulation protocols to either describe or distribute information about humans in any granularity past basic position, orientation, stance, and weapon posture.*

Presently, if two distinct systems are integrated, a character's behaviour does not remain constant. If we consider the continuation of multi-model distributed simulations to be the expected standard, we have to be able to distribute these complex human behaviours consistently across a variety of models. Two significant challenges have prevented this from occurring. First, to transfer and assimilate information, a universally recognized taxonomy is needed. For example, models may disagree on the enumeration to platform mappings or they don't have a specific entity and must substitute it for a more generic version (such as displaying an AC-130U gunship aircraft as a generic C-130 transport aircraft). This becomes even more challenging to universally define intangible human behaviours and actions. Second, physical representations in each model are not universal. How do we guarantee that one model's behaviour matches another's when there could be thousands of variations for the same act? In some cases, these differences may be irrelevant, but for many, it could significantly affect the accomplishment of the training objective.

3.2 Visual Representation of Human Terrain

Human terrain refers to the study of the complex historical, political, socio-cultural, religious, economic, and other considerations to provide detailed information and cultural insight to aid in resolving conflict. In contrast with the dynamics of physical representations, the reasons and motivations for basic human behaviour are influenced by many things outside the scenario/training timeline. Knowing when to transition between physical behaviours and behavioural motivations is crucial. There are a number of different ways to model motivation in people and many different types of representations of social dynamics; however, the goal of Human Terrain Modeling (HTM) in support of training is to model individuals' affinities toward conducting certain activities. Understanding these nuances will better prepare an ethically-minded, tactically-cunning warfighter to succeed in IW operations.

Ethnographic Intelligence is defined as an intelligence collection discipline focused on finding "information about indigenous forms of association, local means of organisation, or traditional methods of mobilisation." Extensive study on human terrain and ethnographic intelligence is essential, as there can be many behavioural differences within different regions. This presents a key challenge in terms of obtaining, normalizing, and using this data. Keeping track of complex, interwoven relationships allows us to understand the general tendencies of the population, how they change over time, and how they would likely influence behaviour of those populations.

3.1.1 Examples JATTL Efforts

The challenge is how to incorporate human terrain and ethnographic intelligence into gaming technology to support effective operational training. While it is possible to create large, complex behavioural models inside the kinetic models, the main approach pursued by USJFCOM is to model and simulate these behaviours in other applications, then gracefully integrate them with individual characters during a training event when required.

USJFCOM's research in this area is aligned with the socio-cultural model used by U.S. Central Command (USCENTCOM) in counterinsurgency (COIN) training, a hybrid of the Political, Military, Economic, Social, Infrastructure, and Information (PMESII) and Areas, Structures, Capabilities, Organizations, People, and Events (ASCOPE) models. This approach allows USJFCOM to model the relative importance of the cultural areas represented in the PMESII model and trace their specific effects on the social areas represented in the ASCOPE model. The result is a set of opinions about the current state of these socio-cultural entities. Aggregate assessments can then be made to determine preferences for or against certain groups and then the

affinity of an individual toward certain courses of action. This allows the character physical behaviours in the model to be driven by their socio-cultural feelings toward the players with which they interact. As well as driving individual behaviours, these PMESII-ASCOPE models are also associated with cultural groups within the society. The groups are then linked to models of cultural networks to allow social interaction between the groups to play out over time, resulting in trends of influence. These networks allow the details of cultural interaction to run outside the simulation and then be brought back in to support training.

3.2 Visual Representation of Physical Terrain

Visual representation of physical terrain includes the appearance of the terrain to include man-made structures (e.g., buildings) and other physical elements (e.g., vegetation). In addition to outdoor terrain, the interiors of buildings must be accurately modelled. Weather conditions ranging from rain, snow, fog, haze, and dust clouds along with lighting conditions/sources are also part of the visual representation of terrain. Terrain must be represented in a realistic manner to provide for an immersive environment.

The physical environment not only provides the setting for training, but also provides constraints and introduces challenges to the conduct of operational tasks. Today's gaming systems do an excellent job in displaying realistic terrain and environmental conditions (rain, fog, snow, wind) however, they do not react to changes in the environment i.e. mobility degradation due to prolonged periods of rain or reduced visibility due to smoke or fog.

As well as the large variety of types of terrain, it is important that terrain have dynamic properties. Basic dynamic properties, such as doors and windows that open and close are important as they often drive human behavioural responses such as cueing and decision processes for tactics, techniques, and procedures (TTP). Warfighters must be able to interact with the physical terrain to achieve training objectives.

By its nature, IW is conducted in remote, rugged, and highly complex terrain (urban and semi-rural) that favour the basic approach of irregular forces; the execution of raids and ambushes on heavy slow moving forces; or, when confronted by superior arms, knowledge of the terrain to slip away. The irregular enemy focuses his use of violence into small areas, shifts them from place to place rapidly, and includes targets and bases of operation in conflict with the Geneva Convention established laws and customs of war. However, IW training simulations are obstructed by two critical issues:

- The continuing lack of high-resolution geospatial data sets over urban areas.
- The inability to represent environmental and weapons effects accurately on terrain.

The demand for geo-specific terrain to support military training is increasing exponentially daily. Accurate terrain data is critical for simulations supporting IW training; however, geospatial data over an urban environment can be difficult to obtain. Additionally, the volume and type of geospatial data required to support high-resolution simulations for IW training is significant (i.e. building types and their specified use, such as residential, commercial, and industrial; specifically hospitals, schools, police stations, power plants, and sub-stations, etc.). Accessing this information in an environment where our forces are conducting military operations on a day-to-day basis adds to the difficulty of collecting this data.

Representation of weapons effects on terrain introduces a requirement for nearly all terrain objects to have some dynamic properties. Constraints and nature of the movement of equipment are frequently the actual subject of training, for example, how a Mine Resistant Ambush Protected (MRAP) sensor moves when in use. The capability for the terrain to accurately reflect the effects of detonations, collisions, and other manmade weapons of destruction is pivotal in developing training that teaches adaptive human behaviour responses.

Note, additional unnecessary detail in the training environment does not necessarily increase the effectiveness of the training. If the level of detail is stressed as an end to itself, rather than a means to achieve the goal of providing a training stimulus, it could actually do the reverse. Immersive training environments need to be mindful of not focusing on non-valid stimuli that could potentially result in a negative training outcome.

Overall, incorporating a dynamic terrain will help develop and reinforce skills, and allow warfighters to practice situational awareness and decision making under stress. Key to this interaction is the trainee's catharsis in the environment, the ability to be cognitively, and to some extent personally, involved with what is being represented instead of the means it is being presented. Dynamic terrain that reacts to changes in the natural and manmade environment combined with the lifelike human behavioural reactions is the next step in providing realistic IW training.

3.2.2 Examples JATTL Efforts

3.2.2.1 Data Collection

JATTL engineers are investigating ways to close the gap in obtaining high-resolution geospatial data. Our terrain engineers regularly conduct field data collections in the United States to obtain geo-specific data for use in building VBS2 terrain databases. Using an array of unsophisticated collections tools such as geo-tagging digital cameras, global positioning systems (GPS), laser ranger finders, tough book computers, and 150' measuring tapes, they collect very specific detailed data to support IW terrain builds. However, in a hostile operational environment, collecting this level of data becomes a real problem.

3.2.2.2 VBS2 Developmental Fieldings

USJFCOM and the Army are conducting a series of developmental fieldings of VBS2 Afghanistan terrain to be used as a mission rehearsal and planning tool. An initial VBS2 terrain database is built by USJFCOM for a specified unit's area of operations (AOR). The database is provided to the unit with sufficient time for pre-deployment training. Units operating in the field need to conduct data collection efforts as often as time and mission permits. Each unit is provided geo-tagging digital cameras as part of their deployable VBS suite for collecting natural or manmade features of significant/key terrain to maintain an operationally geo-specific VBS2 database. The viability of using Unmanned Aerial Vehicles (UAVs) for data collection efforts to augment IW terrain databases is also being researched. Although it is too early in the program to ascertain its success, initial efforts have been well received and feedback has been positive.

3.2.2.3 Training Exercises

Use of dynamic terrain within current models requires a significant change to the way entities are represented on the terrain in regards to mobility, line of sight acquisition, and munitions effects. Data required to support degradation of different soil compositions due to weather effects is complex.

JATTL engineers are investigating ways of incorporating dynamic terrain into models that minimize or negate side effects. Past training exercises that have incorporated weather data have always resulted in negative training because multiple models within the federation did not portray these entities similarly. This resulted in inconsistencies to the training audience.

Presently, the cost of developing dynamic terrain into current models, and the massive data accumulation effort required for accurate soil representation outnumbers the benefits in regards to mobility changes for training exercises. However, dynamic terrain involving munitions and weapons effects is viable and crucial.

3.4 Other Significant Themes

Other trends from the IWTSIPT Final Report emerged as significant themes for consideration. Human behavioural representation in the training stimulus focuses on the details so the information becomes second nature to achieve operational goals. Examples of other identified human behavioural modelling principles/trends are:

- *Language.* The system must provide an environment that supports training in multiple languages. Training should focus on replicating the operational environment to include languages spoken within specific region/location based on the scenario. Training language proficiency is not a requirement found in this trend, rather the achievement of language sufficiency is the goal.
- *Natural verbal and non-verbal communications methods.* This is the process of interfacing with human and simulated entities through verbal and non-verbal communication. Communications may be required between trainees within a unit, other live actors, and simulated entities. Communication method may include voice, gestures, signals, sounds, etc.
- *Autonomous behaviours.* Autonomous behaviours include the ability of the computer generated (CG) forces to have independent behaviours and act/react based upon stimuli. Autonomous behaviours move beyond trainer-provided directions to entities within the environment. The entities/CG forces must be capable of autonomous behaviours such as performing tasks required by friendly, enemy and neutral forces within the environment. Individual and collective tasks are part of autonomous behaviours to include the formation of and participation in crowd situations.
- *Highly detailed scenarios that support training objectives.* Provided the training environment fully supports the requirements identified in the preceding trends, scenarios must also contain sufficient detail and complexity to support training objectives including moral and ethical decision-making. Scenarios must be flexible and adaptable to support various training objectives and include background information for entities, and relevant intelligence products such as human intelligence (HUMINT) and signals intelligence (SIGINT).
- *Geo-specific data repositories.* Provided the training environment fully supports the requirements identified in the preceding trends, repositories of data elements that provide specific details relevant to geo-specific locations must be available. These details include appropriate manner of dress, cultural specific behaviours, building construction, language, etc.

4.0 CONCLUSION

Grounds forces are increasingly turning to gaming technologies to provide synthetic environments for realistic training for engagement with an asymmetric opponent in a complex environment. IW presents a significant number of challenges to provide optimal training to the warfighter. USJFCOM has been involved on several fronts to address these challenges to better train our forces to discern human behaviour subtleties and to act/react in a dynamic complex environment. Creating a multitude of diversified characters and dynamic terrain elements is time consuming and costly. However, to optimize data associations, models require massive amounts of representational and visually detailed data. Research and development efforts in the JATTL are being developed, integrated, and tested as rapidly as possible. Modern serious gaming platforms provide some form of artificial intelligence capability within their core toolset. These range from advanced goal oriented behaviour frameworks to simple finite state machine mechanisms. However, regardless of the complexity, their purpose is rather universal: to autonomously drive humans and other platforms through the virtual world. In order to accomplish this, the infinitely complex world of human dynamics and behaviour

must be broken down into discrete pieces that can be assembled in a variety of configurations in order to outwardly portray a particular behaviour or task. By combining gaming technologies with advanced human modelling, we will narrow the gap to meet our military's needs, maintain a technological lead, and extend our tactical edge on both the linear and nonlinear battlefield. Complex training scenarios with accurate and realistic visual representation of individuals will reinforce observation and profiling skills that will increase situational awareness, threat recognition, and the probability of survival in an IW environment. Advancing human modelling behaviours is pivotal to optimizing individual readiness and organizational effectiveness to support the fight, today and in the future.